R6

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 693 757 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
24.01.1996 Bulletin 1996/04

(51) Int. Cl.^{6}: **H01F 27/29**, H01F 41/10,
H01F 17/04

(21) Application number: 95111223.4

(22) Date of filing: 18.07.1995

(84) Designated Contracting States:
DE FR GB

(30) Priority: 20.07.1994 JP 167942/94
08.05.1995 JP 109246/95

(71) Applicant: MATSUSHITA ELECTRIC INDUSTRIAL
CO., LTD.
Kadoma-shi, Osaka 571 (JP)

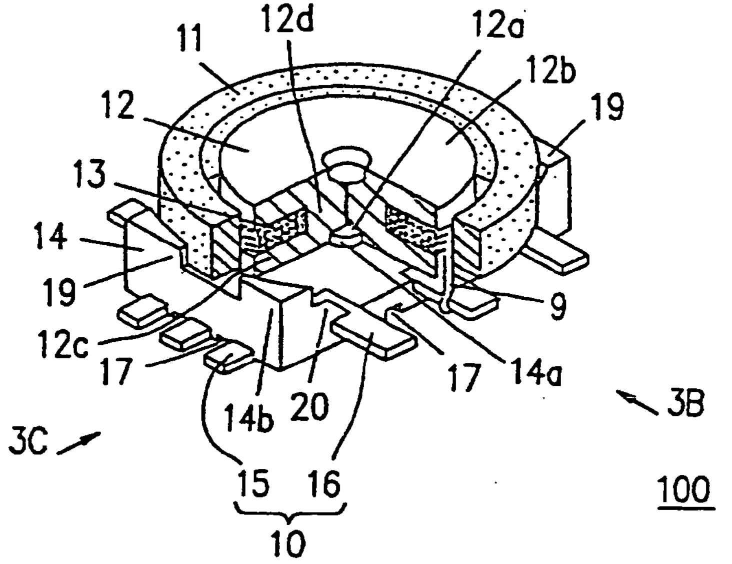
(72) Inventors:
- Tsutsumi, Yutaka
  Neyagawa-shi, Osaka (JP)
- Momoi, Hiroshi
  Hirakata-shi, Osaka (JP)
- Kuwata, Haruhiko
  Osaka-shi, Osaka (JP)
- Nakamura, Shinji
  Matsudo-shi, Chiba-ken (JP)
- Shinada, Makoto
  Yawata-shi, Kyoto (JP)

(74) Representative: Kügele, Bernhard et al
CH-1202 Genève (CH)

(54) Inductor and method for producing the same

(57) In an inductor including a magnetic core on a top surface of a terminal table, a plurality of L-shaped conductors are inserted into the terminal table so that two ends of each of the L-shaped conductors are projecting from a side surface of the terminal table. The plurality of L-shaped conductors each have at least one stepped portion. One of the two ends which is on a higher level than the stepped portion acts as a winding terminal around which the wire is wound, and the other end which is on a lower level than the stepped portion acts as a mounting terminal used for mounting of the inductor. The winding terminal is projecting from a higher level of the side surface of the terminal table than the mounting terminal.

FIG. 1



Printed by Rank Xerox (UK) Business Services
2.9.7/3.4

Description

BACKGROUND OF THE INVENTION

1. Field of the Invention:

The present invention relates to an inductor for surface mounting used for a battery-driven electronic device or the like and a method for producing the same.

2. Description of the Related Art:

Figure 14 is a partially cut perspective view of a conventional inductor **50**. Figure 15 is an isometric view of a terminal **31** of the inductor **50**. Figures **16A** through **16E** are isometric views illustrating a method for producing the inductor **50**.

As shown in Figures **14** and **15**, the terminal **31** is drawn outside from an intermediate level part of a side surface of a terminal table **30** (namely, an intermediate part of the side surface in the thickness direction). The terminal **31** is bent to be step-like. The terminal **31** includes a tip portion **31a**, and the inductor **50** is mounted on an electronic device or the like in the state where a bottom surface of the tip portion **31a** is in contact with a substrate of the electronic device or the like. The bottom surface of the tip portion **31a** is on the same level as a bottom surface of the terminal table **30**.

On a top surface of the terminal table **30**, a drum-shaped core **28** is provided. The drum-shaped core **28** has a top flange **28b**, a bottom flange **28c**, and a central part **28a** interposed between the top flange **28b** and the bottom flange **28c** and having a smaller diameter than the top and bottom flanges **28b** and **28c**. A wire **29** is wound around the central part **28a**. Two ends **34** (only one is shown in Figure **14**) of the wire **29** are wound around a foot of the terminals **31** on the terminal table **30** and are treated by, for example, soldering for more secure electric connection to the terminals **31**.

A cap-like core **27** covers the drum-shaped core **28**, and is adhered to the terminal table **30** at contact surfaces thereof. The cap-like core **27** and the drum-shaped core **28** form a magnetic core of the inductor **50**.

A method for producing an inductor **50** will be described with reference to Figures **16A** through **16E**.

As shown in Figure **16A**, a prescribed pattern is punched in a strip-like metal plate **33** by a pressing mold to form a lead frame **32** having guide holes **35** at prescribed positions and T-shaped terminal strips **31b** extending inward from the lead frame **32**. Next, the lead frame **32** is set in a resin molding apparatus (not shown). Then, insert molding is performed using a mold to form a terminal table **30** having the T-shaped terminal strips **31b** inserted therethrough, as shown in Figure **16B**.

Next, the terminal strips **31b** are cut to separate the terminal table **30** from the lead frame **32** as is shown in Figure **16C**. As shown in Figure **16D**, the terminal strips **31b** are bent using a press mold to obtain step-like terminals **31**.

Then, as shown in Figure **16E**, a drum-shaped core **28** is adhered on a top surface of the terminal table **30**. A wire **29** is wound around a central part **28a** of a drum-shaped core **28**, and a cap-like core **27** (Figure **14**) is provided to cover the drum-shaped core **28** to form a magnetic core. Thus, the inductor **50** is completed.

As described above, the step-like terminals **31** of the conventional inductor **50** are formed by bending the T-shaped terminal strips **31b** inserted through the terminal table **30**. When the terminal strips **31b** are bent, a mechanical stress is applied. Such a mechanical stress often causes generation of cracks in the terminal table **30**, thereby lowering the mechanical strength of the terminals **31**.

By bending the terminal strips **31b** in this manner, the shape and the size of the terminals **31** are difficult to controll with high precision. In the case where the terminals **31** do not have the shape and the size as designed, the inductor **50** including such terminals is not electrically connected to a printed circuit board in a satisfactory manner when the inductor **50** is mounted on a surface of the printed circuit board, resulting in defective mounting.

In the conventional inductor **50**, two ends **34** of the wire **29** are wound around a foot of the terminals **31**, which extend from the terminal table **30**, and further soldered for more secure electric connection to the terminals **31**. The winding process also provides a mechanical stress and thus can cause non-uniformity in the size of the terminals **31**. Such difficulty in obtaining a satisfactorily precise size often causes defective mounting.

Moreover, in the conventional method for producing the inductor **50**, after the terminal table **30** having the T-shaped terminal strips **31b** inserted therethrough is formed by insert molding, the terminal strips **31b** are cut to separate the terminal table **30** from the lead frame **32**. The terminal table **30** having the terminal strips **31b** inserted therethrough, namely, an inductor in a half-completed state, is transported for further processing. During the transportation, the terminals **31** are exposed to mechanical stress, resulting in lower reliability and lower size precision of the terminals **31**.

SUMMARY OF THE INVENTION

According to one aspect of the present invention, an inductor includes: a terminal table having a projecting portion at each of four corners of a top surface thereof; a plurality of L-shaped conductors inserted through the terminal table and each having two ends projecting from a side surface of the terminal table; and a magnetic core located on the top surface of the terminal table. The magnetic core includes at least a drum-shaped core having a wire wound around a central part thereof. The plurality of L-shaped conductors each have at least one stepped portion between the two ends. One of the two ends which is on a higher level than the stepped portion acts as a winding terminal around which the wire is allowed to be wound, and the other end which is on a lower level than

European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 95 11 1223

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X Y	DE-A-42 23 097 (TDK CORP) 21 January 1993 * column 2, line 38 - column 3, line 52; figures * ---	1,4-7 9,10,13	H01F27/29 H01F41/10 H01F17/04
Y	EP-A-0 212 812 (MATSUSHITA ELECTRIC IND CO LTD) 4 March 1987 * page 7, line 14 - line 26; figure 3 * ---	9,10,13	
A	PATENT ABSTRACTS OF JAPAN vol. 008 no. 217 (E-270) ,4 October 1984 & JP-A-59 101811 (NAGANO NIPPON MUSEN KK) 12 June 1984, * abstract * ---		
A	PATENT ABSTRACTS OF JAPAN vol. 008 no. 074 (E-236) ,6 April 1984 & JP-A-58 223306 (TOUKOU KK) 24 December 1983, * abstract * -----		

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

H01F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	20 October 1995	Marti Almeda, R

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

FIG.16A

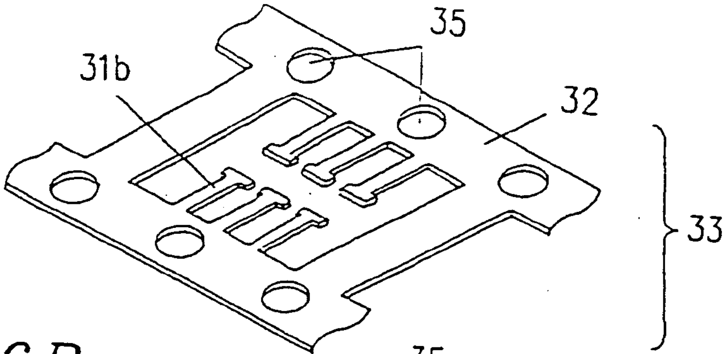


FIG.16B

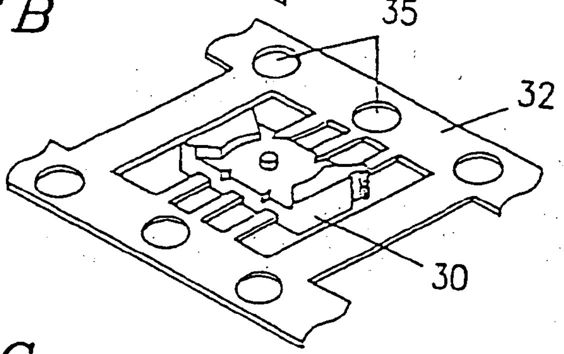


FIG.16C

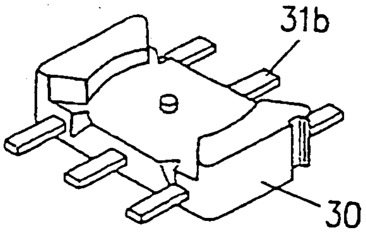


FIG.16D

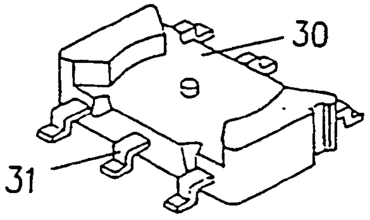


FIG.16E

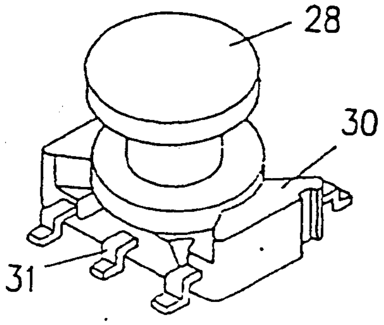


FIG.14

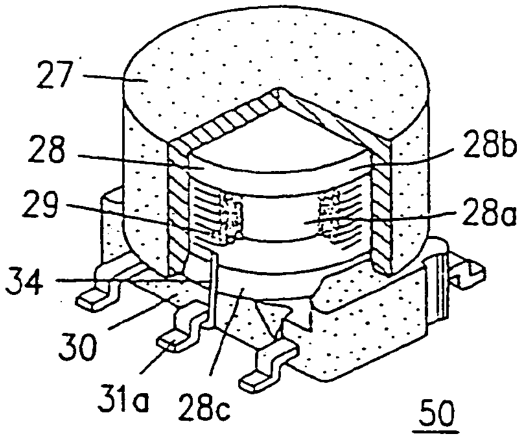
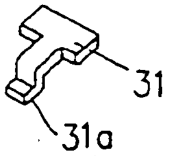


FIG.15



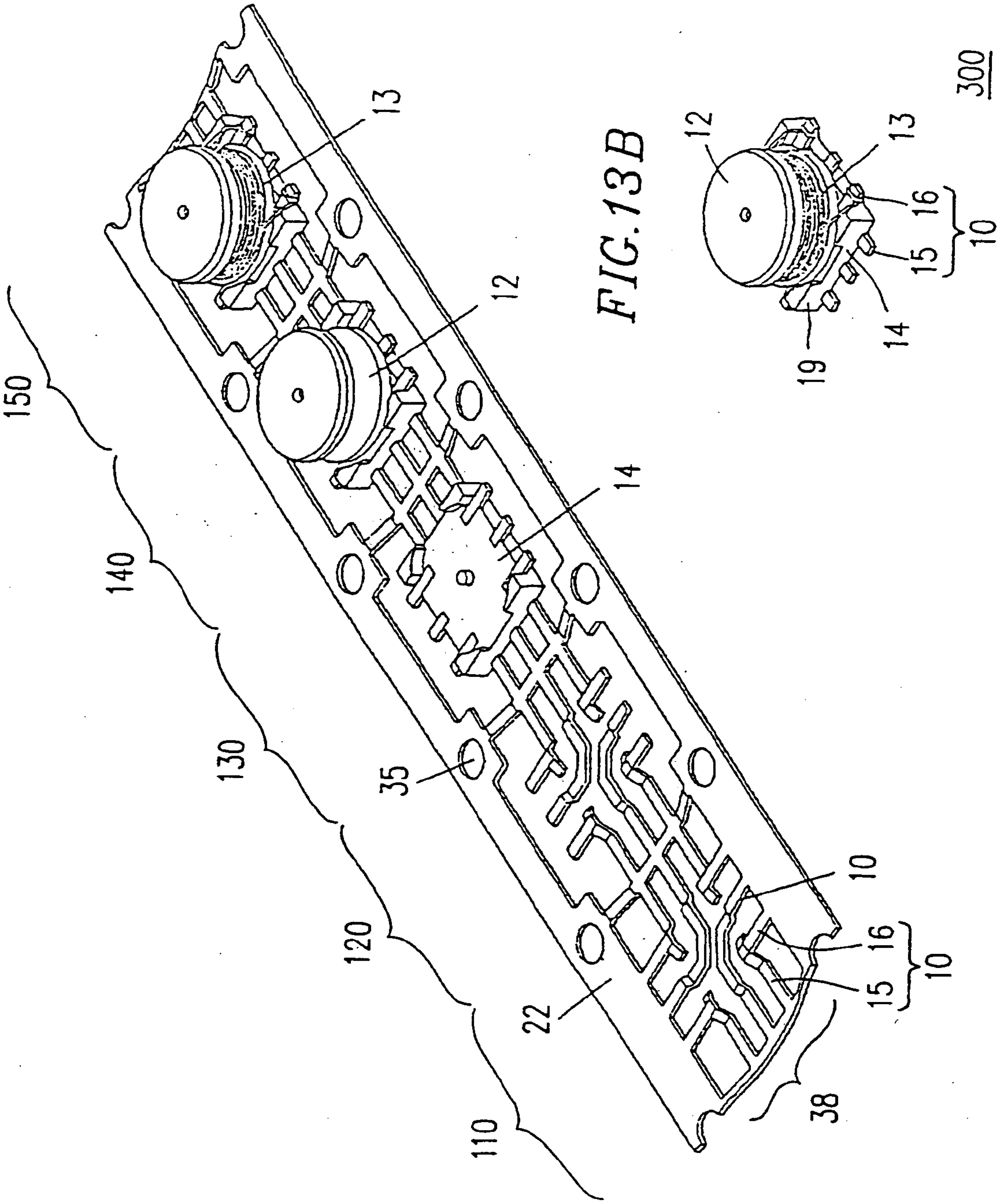


FIG.13A

FIG.13B

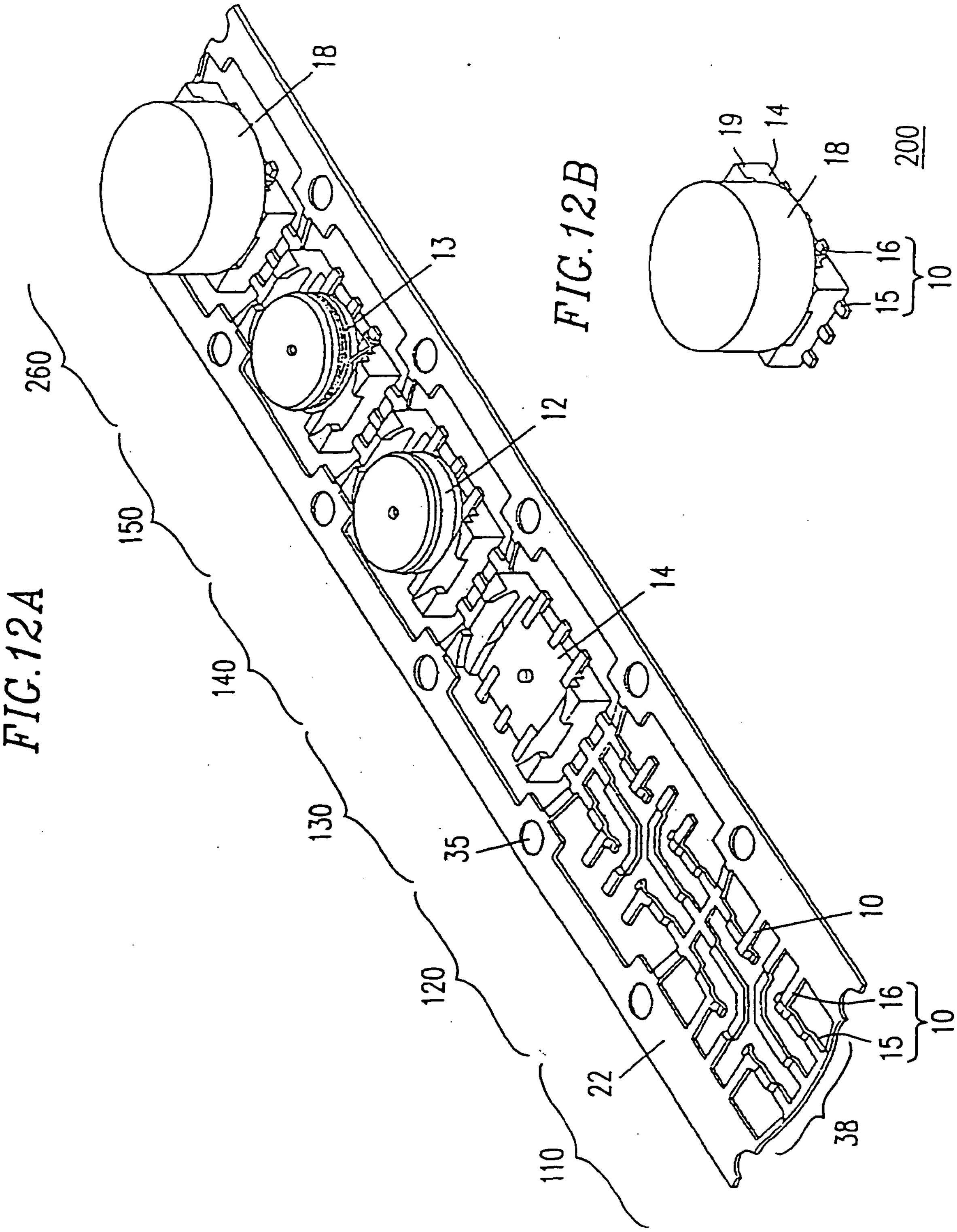


FIG.12A

FIG.12B

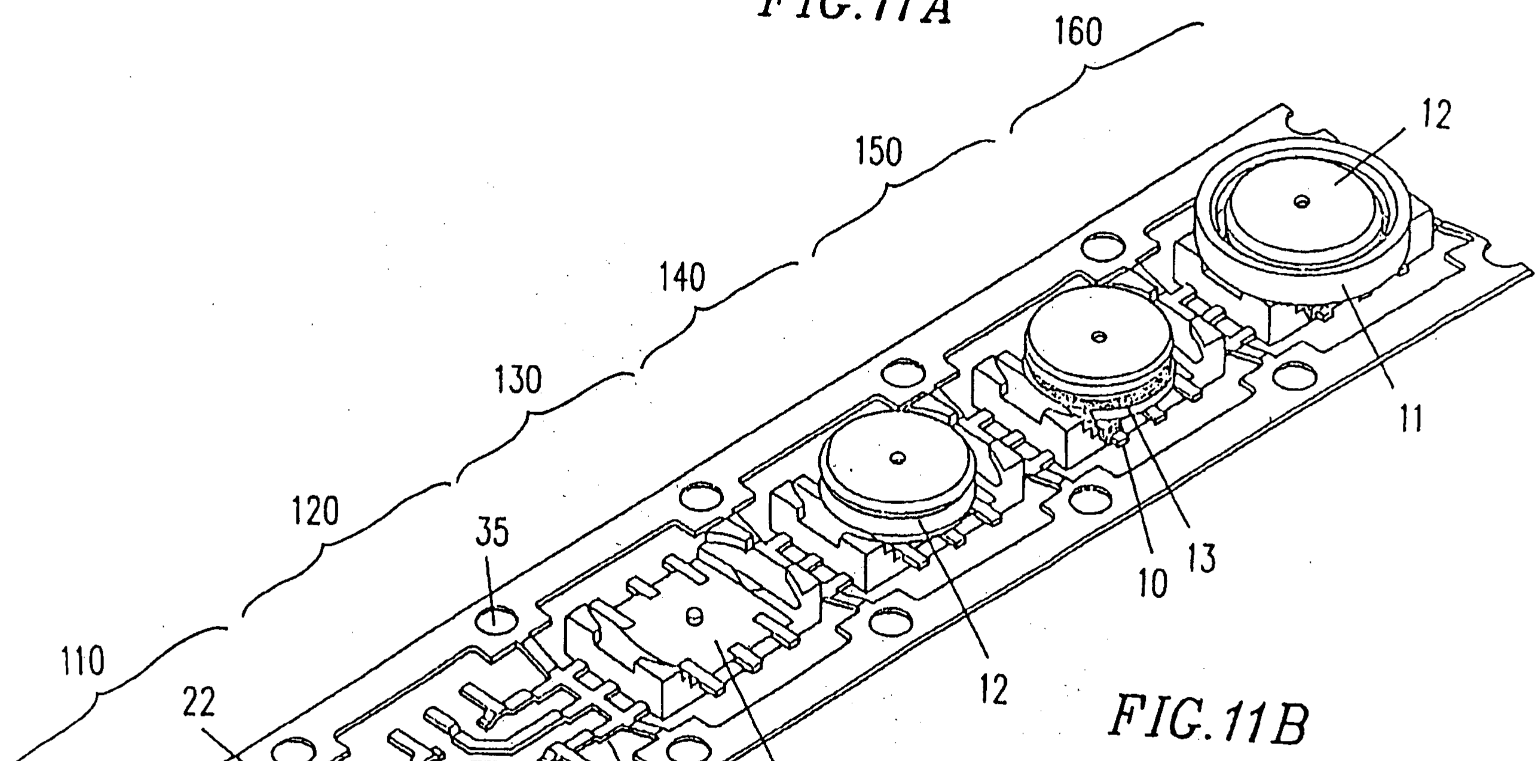


FIG.11A

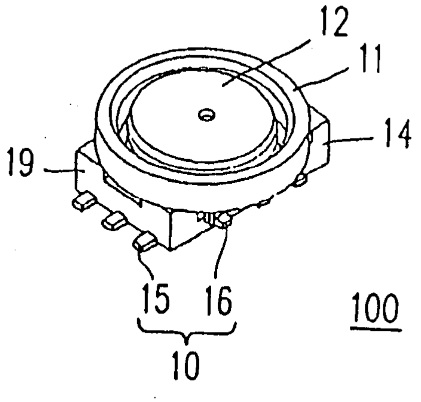


FIG.11B

FIG. 10

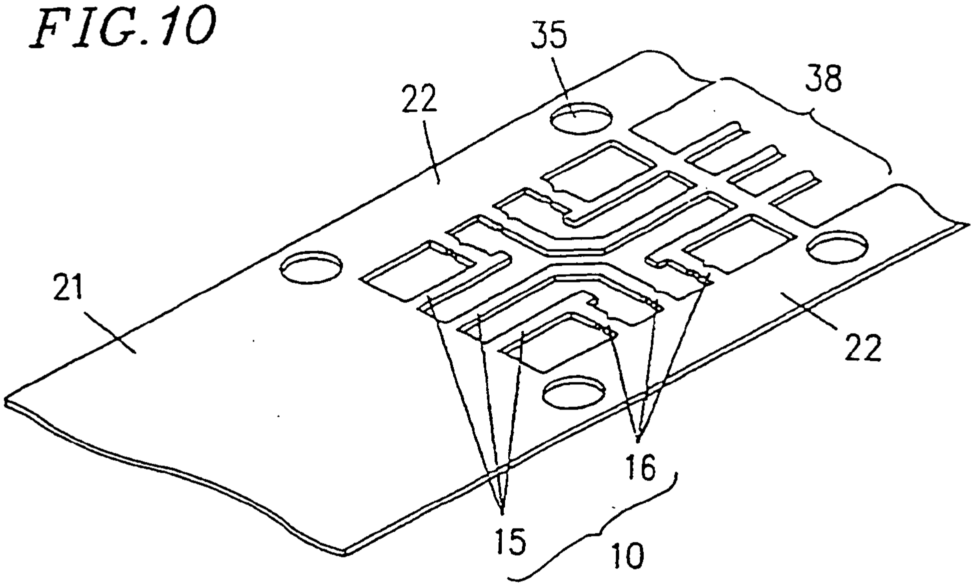


FIG. 8

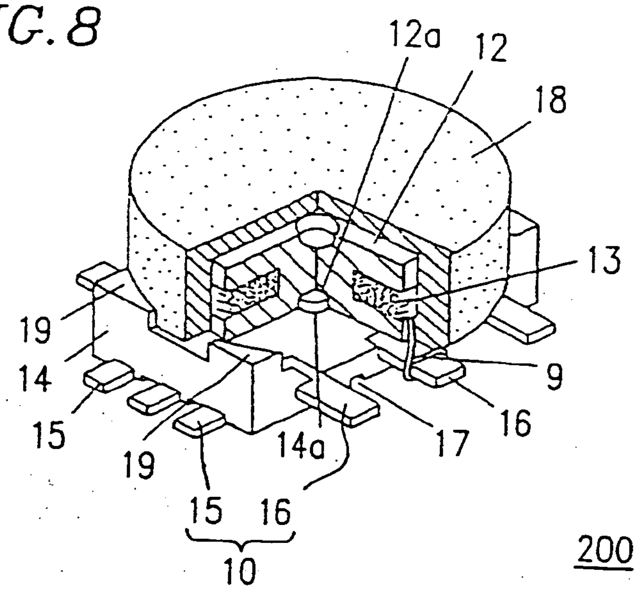


FIG. 9

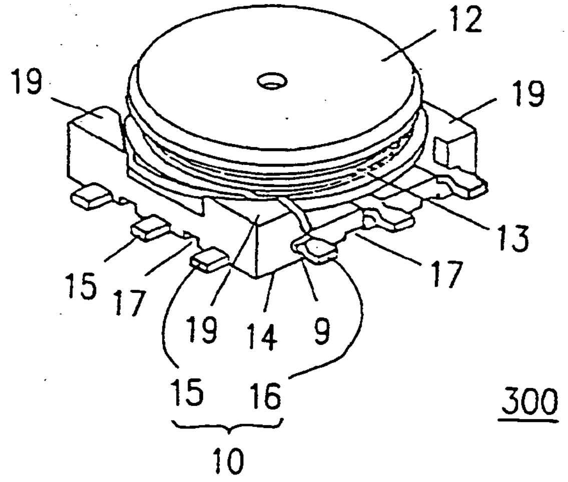


FIG. 6

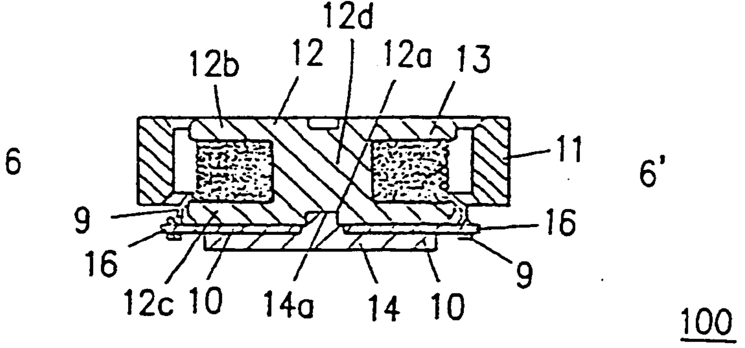


FIG. 7

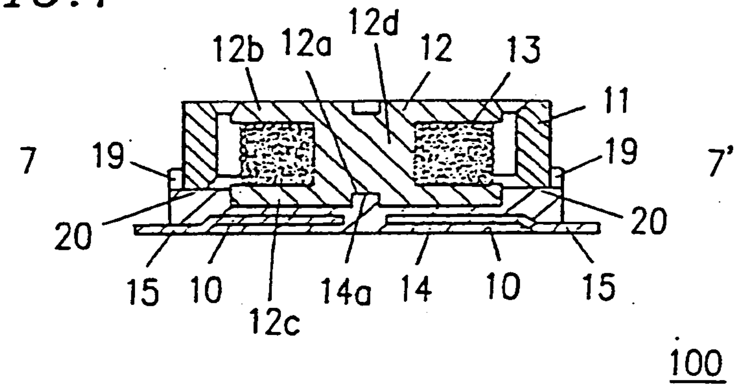


FIG. 4

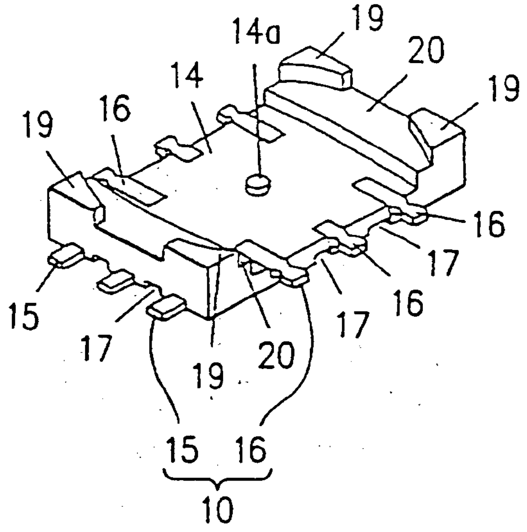


FIG. 5

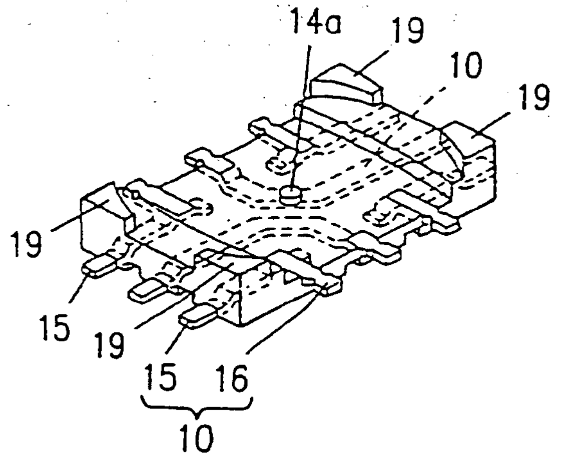


FIG. 3A

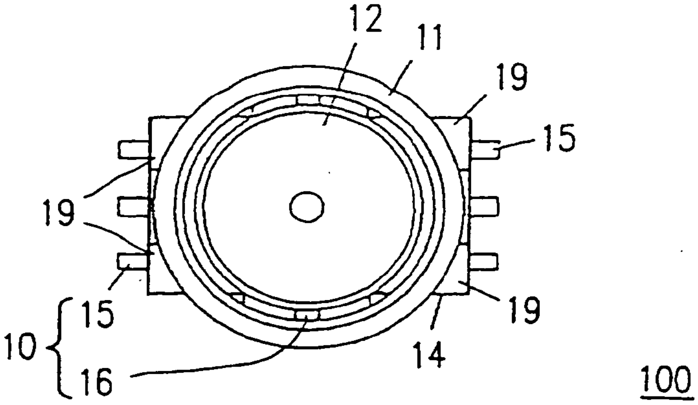


FIG. 3B

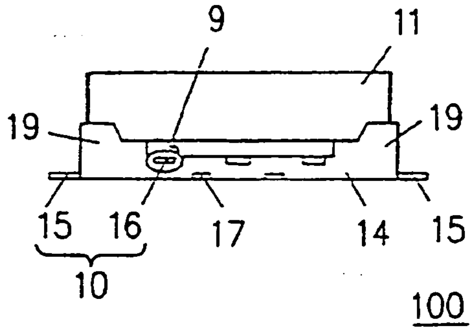


FIG. 3C

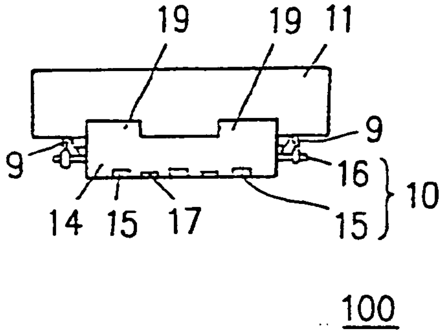


FIG. 3D

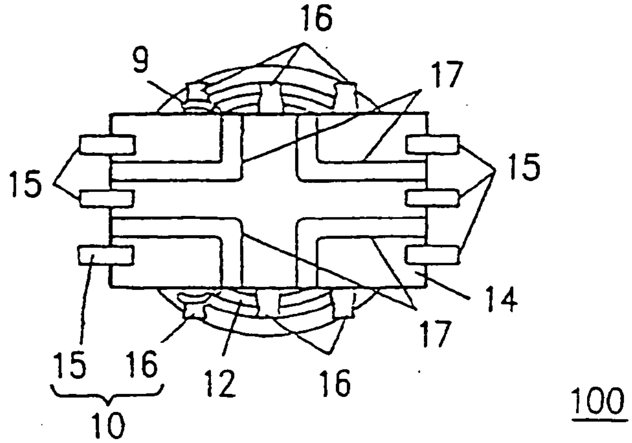


FIG.1

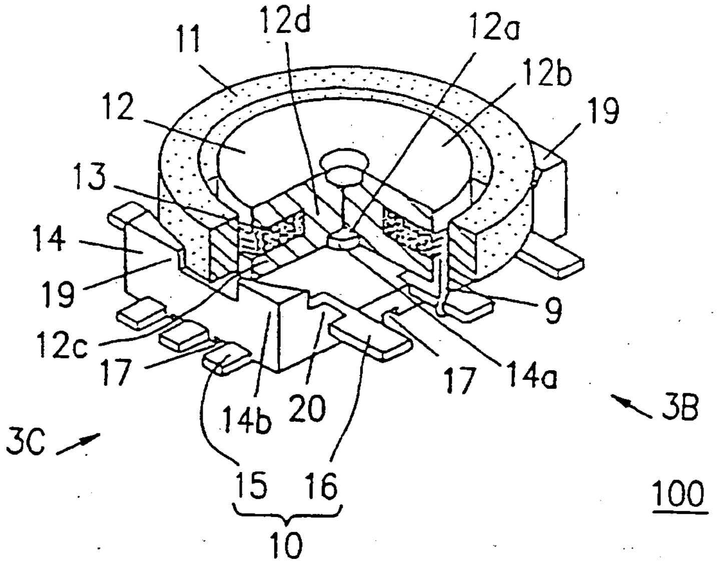
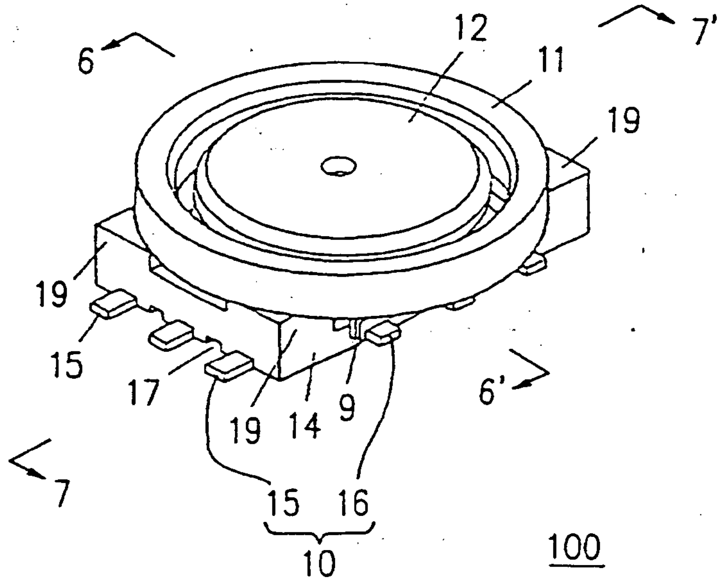

3B
3C

FIG.2



is held by an inner side circumferential surface of each of the projecting portions.

6. An inductor according to claim 5, wherein the another core is a cylindrical core located around the outer circumferential surface of the drum-shaped core.

7. An inductor according to claim 5, wherein the another core is a cap-like core covering a top surface and the outer circumferential surface of the drum-shaped core.

8. An inductor according to claim 1, wherein the level of the mounting terminals and the level of the winding terminals have a difference of approximately 0.2 mm to 1.0 mm, and the plurality of L-shaped conductors each have two stepped portions.

9. A method for producing an inductor, comprising the steps of:

treating a strip-like metal plate with press working to form a lead frame and a terminal area interposed between two areas of the lead frame extending in a longitudinal direction of the strip-like metal plate, the lead frame and the terminal area being formed in a prescribed pattern;

mounting a terminal table on the terminal area;

mounting a magnetic core on the terminal table;

winding a wire around the magnetic core; and

separating an assembly including the terminal table, magnetic core, and the wire from the lead frame.

10. A method according to claim 9, wherein:

the terminal area includes a plurality of L-shaped conductors, and

the step of treating the strip-like metal plate with press working includes the step of forming at least one stepped portion in each of the plurality of L-shaped conductors to obtain a prescribed level difference between the level of one of two ends of each L-shaped conductor and the level of the other end of the L-shaped conductor.

11. A method according to claim 10, wherein the step of forming at least one stepped portion includes the step of bending each of the L-shaped conductors a plurality of times to form two stepped portions to obtain the level difference of approximately 0.2 mm to 1.0 mm.

12. A method according to claim 9, further including the step of cutting off a part of each of the plurality of L-shaped conductors extending in a width direction of the strip-like metal plate from the lead frame before the step of mounting the terminal table.

13. A method according to claim 9, wherein:

the terminal area includes a plurality of L-shaped conductors,

the step of treating the strip-like metal plate with press working includes the step of forming at least one stepped portion in each of the plurality of L-shaped conductors to obtain a prescribed level difference between the level of one of two ends of each L-shaped conductor and the level of the other end of the L-shaped conductor,

one of the two ends which is on a higher level than the stepped portion acts as a winding terminal around which the wire is allowed to be wound, and the other end which is on a lower level than the stepped portion acts as a mounting terminal used for mounting of the inductor, and

the terminal table is mounted on the terminal area in such a manner as to allow the winding terminal to project from a higher level of a side surface of the terminal table than the mounting terminal.

i.e., the size of the terminal table **14**. In the case where the prescribed level difference between the mounting terminal **15** and the winding terminal **16** is not sufficiently large, a one-stage bending process can be used.

The parameters for the press working and insert molding in the other steps can be the same as in conventional methods, and detailed description thereof will be omitted.

The materials for the strip-like metal plate **21** and the terminal table **14** are not limited to those mentioned above.

The bottom surface of the terminal table **14** can be square instead of rectangular.

As has been described so far, in an inductor according to the present invention, the winding terminals around which the ends of the wire are wound are projecting from an intermediate level part of the side surface of the terminal table. The mounting terminals used for connection of the inductor to a printed circuit board have a bottom surface which is on the same level as the bottom surface of the terminal table. The mounting terminals and the winding terminals of the inductor according to the present invention are independent from each other, whereas the same type of conductors are used for mounting terminals and winding terminals in a conventional inductor. According to the present invention, the mounting terminals and the winding terminals extend straight from the terminal table without being bent outside the terminal table.

Due to such mounting terminals and winding terminals, deterioration in mechanical strength of the inductor is prevented. Further, the size precision of the terminals is improved, and deformation thereof is avoided. Thus, the mounting qualities such as positional precision with respect to the printed circuit board and mounting reliability are improved.

Since the element or the elements of the magnetic core can be positioned and held by the projections (for example, the projecting portions **19** and the stepped-up portions **20**) on the terminal table, the inductor can be assembled more easily and be more stably seated.

Since the inductor is separated from the lead frame at the final stage of the production, the inductor is not transported in the state of being half-completed. Thus, application of a mechanical stress on the terminals can be avoided, thus realizing improvement in size precision and prevention of deformation of the terminals. As a result, reliability is enhanced.

The winding terminals formed by bending the L-shaped conductors and extending in a width direction of the strip-like metal plate are cut off from the lead frame immediately before the formation of the terminal table. Accordingly, the terminal table is not supplied with a mechanical stress even if a mechanical stress is applied to the lead frame when, for example, the strip-like metal plate is rolled around a reel for temporary storage, thus preventing breakage of or generation of cracks in the terminal table.

Various other modifications will be apparent to and can be readily made by those skilled in the art without departing from the scope and spirit of this invention. Accordingly, it is not intended that the scope of the claims appended hereto be limited to the description as set forth herein, but rather that the claims be broadly construed.

Claims

1. An inductor, comprising:

a terminal table having a projecting portion at each of four corners of a top surface thereof;

a plurality of L-shaped conductors inserted through the terminal table and each having two ends projecting from a side surface of the terminal table; and

a magnetic core located on the top surface of the terminal table, wherein:

the magnetic core includes at least a drum-shaped core having a wire wound around a central part thereof, and

the plurality of L-shaped conductors each have at least one stepped portion between the two ends, one of the two ends which is on a higher level than the stepped portion acts as a winding terminal around which the wire is allowed to be wound, and the other end which is on a lower level than the stepped portion acts as a mounting terminal used for mounting of the inductor, the winding terminal being projecting from a higher level of the side surface of the terminal table than the mounting terminal.

2. An inductor according to claim 1, wherein the terminal table has at least one groove running from one side to another side of a bottom surface thereof.

3. An inductor according to claim 1, wherein the terminal table has a projection on the top surface thereof, the drum-shaped core has a bottom flange including a bottom surface of the drum-shaped core, and the bottom flange has a recess in the bottom surface, the recess being engageable with the projection of the terminal table.

4. An inductor according to claim 1, wherein the drum-shaped core has an outer circumferential surface which is held by an inner side circumferential surface of each of the projecting portions.

5. An inductor according to claim 1, wherein:

the terminal table further has a stepped-up portion between the top surface thereof and the projecting portions, and

the magnetic core further includes another core located around the drum-shaped core, the drum-shaped core having an outer circumferential surface which is held by an inner side circumferential surface of the stepped-up portion, and the another core having an outer circumferential surface which winding terminal **16**. The bending process is performed in two stages for the following reason.

The level difference between the winding terminal **16** and the mounting terminal **15** is approximately 0.2 mm to 1.0 mm and preferably 0.4 mm. The precision of press working is not necessarily sufficiently high. Accordingly, in the case of performing a one-stage bending process to obtain the above-mentioned level difference, a sufficiently high size precision as required cannot be achieved because of a large tensile stress applied to the L-shaped conductor **10**. A multiple-stage bending process of bending the L-shaped conductor **10** at a plurality of positions is adopted in order to achieve the prescribed high precision.

At the next step, as is shown in part **120** in Figure **11A**, the ends of the L-shaped conductor **10** to be the winding terminals **16** are cut off from the lead frame **22**.

As is shown in part **130** in Figure **11A**, the terminal table **14** is provided in the terminal area **38** by insert molding. In detail, the terminal table **14** is formed by injecting a molten resin into a mold in a resin molding apparatus and inserting a part of the terminal area **38** in the molten resin before the resin is solidified. Before such insert molding, the strip-like metal plate **21** is set in the resin molding apparatus using the guide holes **35**. The ends to be the winding terminals **16** are cut off from the lead frame **22** immediately before the insert-molding of the terminal table **14**. The guide holes **35** are also used for rolling the strip-like metal plate **21** around a reel for temporary storage during the production of the inductor **100**.

The terminal table **14** is typically formed of an epoxy resin. Alternatively, a phenol resin, a diallylphthalate resin or a polybutadieneterephthalate, or the like can be used for the terminal table **14**.

Next, as is shown in part **140** in Figure **11A**, the drum-shaped core **12** formed of ferrite is provided on a top surface of the terminal table **14** as a part of the magnetic core. As is shown in part **150** in Figure **11A**, a wire **13** formed of a copper wire covered with an insulating material is wound around the central part **12d** of the drum-shaped core **12**. Then, the ends **9** of the wire **13** are wound around the winding terminals **16** to be connected to the terminal table **14**.

As is shown in part **160** in Figure **11A**, the cylindrical core **11** formed of ferrite is fixed on the terminal table **14**. The mounting terminals **15** are cut off from the lead frame **22** to obtain the inductor **100** shown in Figure **11B**.

The above-described method for producing the inductor **100** has the following features.

The inductor **100** is separated from the lead frame **22** of the strip-like metal plate **21** at the final step of the production method, but not immediately after the terminal table **14** is formed by insert molding. The assembly of the inductor **100** after the formation of the terminal table **14** is performed in the state where the terminal table **14** is still connected to the lead frame **22**. Accordingly, the inductor **100** is not transported in the state of being half-completed, thus restricting the mechanical stress applied to the mounting terminals **15** and the winding terminals **16**. As a result, the L-shaped conductors **10** are not deformed and are improved in size precision and reliability.

As is described above, the winding terminals **16** which are formed by the bending the L-shaped conductor **10** are cut off immediately before the formation of the terminal table **14**. Thus, the terminal table **14** which is connected to the strip-like metal plate **21** by insert molding is not directly connected to the lead frame **22**.

Generally, a strip-like metal plate is wound around a reel in order to temporarily store the strip-like metal plate during the production process of an inductor. While the strip-like metal plate is being rolled around the reel, a stress is applied to the lead frame in a longitudinal direction thereof. In the above-described method according to the present invention, even if such a stress is applied to the lead frame **22**, the terminal table **14** is not supplied with a mechanical stress, thus preventing breakage of or generation of cracks in the terminal table **14**.

The method described above is for producing the inductor **100** including the cylindrical core **11** and the drum-shaped core **12**. The inductors **200** and **300** (Figures **8** and **9**) can also be produced in similar manners.

Figure **12A** shows various steps of a method for producing the inductor **200** including the cap-like core **18** which covers the drum-shaped core **12**. The cap-like core **18** is mounted after the provision of the drum-shaped core **12** and the connection of the wire **13** to the winding terminal **16**, as is shown in part **260** in Figure **12A**. After the cap-like core **18** is mounted, the mounting terminals **15** are cut off from the lead frame **22** to obtain the inductor **200** shown in Figure **12B**. The other production steps of the inductor **200** shown in Figure **12A** are the same as the corresponding producing steps of the inductor **100** shown in Figure **11A**.

Figure **13A** shows various steps of a method for producing the inductor **300** in which only the drum-shaped core **12** forms the magnetic core. After the provision of the drum-shaped core **12** and the connection of the wire **13** to the winding terminal **16** (part **150** in Figure **13A**), the mounting terminals **15** are cut off from the lead frame **22** to obtain the inductor **300** shown in Figure **13B**. The other production steps of the inductor **300** shown in Figure **13A** are the same as the corresponding producing steps of the inductor **100** shown in Figure **11A**.

In the bending process of the L-shaped conductors **10**, the pressing pressure in the first stage and the second stage is typically approximately 20 N/cm^2 to 100 N/cm^2, and preferably approximately 50 N/cm^2. The pressing pressure can be set at any optimum value in accordance with the material, the thickness and the like of the strip-like metal plate **21**.

In the above-described example, the L-shaped conductors **10** are treated with a two-stage bending process; however, the present invention is not limited to this. A three- or more-stage bending process can be adopted in accordance with a prescribed level difference between the mounting terminal **15** and the winding terminal **16**, First, the drum-shaped core **12** is positioned on the terminal table **14** by engaging the projecting portion **14a** of the terminal table **14** in the recess **12a** of the drum-shaped core **12**. By forming each of the stepped-up portions **20** to have such a curved inner side surface as to match an outer circumferential surface of the bottom flange **12c** of the drum-shaped core **12**, the stepped-up portions **20** can be used also for horizontal positioning and holding of the drum-shaped core **12**. Due to such a curved inner side surface, the positioning of the drum-shaped core **12** on the terminal table **14** can be performed more easily and more precisely. Such a shape of the stepped-up portions **20** also allows the drum-shaped core **12** to be supported by the terminal table **14** more securely.

The cylindrical core **11** forming an outer portion of the magnetic core is horizontally positioned on the terminal table **14** by contacting an outer circumferential surface of the cylindrical core **11** on an inner side surface of each projecting portion **19**. Then, the cylindrical core **11** is adhered on the projecting portions **19**. In order to allow the positioning of the cylindrical core **11** more easily, the inner side surface of each projecting portions **19** is formed to be curved so as to match the outer circumferential surface of the cylindrical core **11**.

A bottom surface of the cylindrical core **11** is on the stepped-up portions **20**. Thus, as is shown in Figures **6** and **7**, there is a gap formed between the bottom surface of the bottom flange **12c** of the drum-shaped core **12** and the bottom surface of the cylindrical core **11**. The ends **9** of the wire **13** are drawn through the gap as is shown in Figures **3B** and **3C** in order to prevent the wire **13** from being disconnected.

As is shown in Figure **3D**, the bottom surface of the terminal table **14** has grooves **17** running from the longer sides to the shorter sides thereof. The grooves **17** have the following effect.

During a process for surface-mounting an inductor on a printed circuit board, a solder flux or a solder flux diluting agent often goes into the gap between the bottom surface of the inductor (namely, the bottom surface of the terminal table) and the printed circuit board. When the solder flux or the solder flux diluting agent which goes into the gap is vaporized by the heat used for soldering, the position at which the inductor is mounted is deviated by the pressure of the gas generated by the vaporization. In the case where the inductor has the grooves **17**, the gas goes out through the grooves **17**, thus preventing the deviation of the position of the inductor relative to the printed circuit board.

In the inductor **100** described above, the magnetic core includes the drum-shaped core **12** and the cylindrical core **11** surrounding the drum-shaped core **12**. Alternatively, as in the case of an inductor **200** shown in Figure **8**, the cylindrical core **11** can be replaced with a cap-like core **18** which covers the drum-shaped core **12**.

Still alternatively, as in the case of an inductor **300** shown in Figure **9**, a magnetic core can be formed only of the drum-shaped core **12**. In such a case, the inductor **100** does not include any element equivalent to the cylindrical core **11**. Accordingly, the drum-shaped core **12** can be positioned by the projecting portions **19** without the provision of the stepped-up portions **20**. In detail, the outer circumferential surface of the bottom flange **12c** of the drum-shaped core **12** is positioned along the inner side surfaces of the projecting portions **19**. Thus, reduction in the number of the production steps and simplification of the shape of the elements can be achieved, resulting in reduction in the production cost.

With respect to Figures **10**, **11A** and **11B**, a method for producing the inductor **100** will be described.

Figure **10** is an isometric view of a strip-like metal plate **21** used for producing the inductor **100**. Figure **11A** is an isometric view of the strip-like metal plate **21**, illustrating a method for producing the inductor **100**. In Figure **11A**, parts **110**, **120**, **130**, **140**, **150** and **160** respectively indicate various production steps of the inductor **100**. Figure **11B** is a perspective view of the inductor **100** in a completed state. In Figures **11A** and **11B**, the grooves **17** are omitted for simplicity.

As is shown in Figure **10** and **11**, the strip-like metal plate **21** is treated with press working to form a prescribed pattern having a lead frame **22** extending along longitudinal sides of the metal plate **21** and a plurality of terminal areas **38** interposed between the two extending parts of the lead frame **22**. Each terminal area **38** corresponds to one inductor **100**. The lead frame **22** have a plurality of pairs of guide holes **35** formed at a prescribed interval. Each terminal area **38** is substantially rectangular and defined by two pairs of guide holes **35**. Each terminal area **38** further include six L-shaped conductors **10** each of which has two ends to be formed into the winding terminal **16** and the mounting terminal **15**.

The strip-like metal plate **21** is typically formed of phosphor bronze. Alternatively, german silver, brass, iron or the like can be used for the strip-like metal plate **21**. The width of the strip-like metal plate **21** (perpendicular to the longitudinal direction) is typically approximately 8 mm to 24 mm, and preferably approximately 12 mm. The thickness of the strip-like metal plate **21** is typically approximately 0.1 mm to 0.4 mm and preferably approximately 0.2 mm.

Next, as is shown in part **110** in Figure **11A**, the L-shaped conductors **10** are bent by a clamping pressure system to have a stepped portion. Thus, each L-shaped conductor **10** is shaped so that one of the two ends thereof to be the mounting terminal **15** projects downward from the level of the lead frame **22** and that the other end thereof to be the winding terminal **16** projects upward from the level of the lead frame **22**. Thus, the level of the mounting terminal **15** and the level of the winding terminal **16** have a prescribed difference.

The bending process is performed in two stages. In a first stage, the L-shaped conductor **10** are bent at a position **10X** between the end to be the mounting terminal **15** and an intermediate step **10a**. In a second stage, the L-shaped conductor **10** is bent at a position **10Y** between the intermediate step **10a** and the end to be the

Figure **8** is a partially cut perspective view of an inductor in a modification of the inductor shown in Figure **2**;

Figure **9** is a partially cut perspective view of an inductor in another modification of the inductor shown in Figure **2**;

Figures **10** and **11A** are isometric views of a strip-like metal plate, illustrating a method for producing the inductor shown in Figure **2**;

Figure **11B** is a perspective view of the inductor in a completed state;

Figure **12A** is an isometric view of a strip-like metal plate, illustrating a method for producing the inductor shown in Figure **8**;

Figure **12B** is a perspective view of the inductor shown in Figure **8** in a completed state;

Figure **13A** is an isometric view of a strip-like metal plate, illustrating a method for producing the inductor shown in Figure **9**;

Figure **13B** is a perspective view of the inductor shown in Figure **9** in a completed state;

Figure **14** is a perspective view of a conventional inductor;

Figure **15** is an isometric view of a terminal of the conventional inductor shown in Figure **14**; and

Figures **16A** through **16E** are isometric views illustrating various steps of a method for producing the inductor shown in Figure **14**.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinafter, the present invention will be described by way of illustrative examples with reference to the accompanying drawings.

Figure **1** is a partially cut perspective view of an inductor **100** in an example according to the present invention. Figure **2** is a perspective view showing an appearance thereof. Figure **3A** is a top view of the inductor **100**, Figures **3B** and **3C** are side views of the inductor **100** seen in the directions of arrows **3B** and **3C** in Figure **1**, respectively. Figure **3D** is a bottom view of the inductor **100**. Figure **4** is an isometric view of a terminal table **14** and terminals of the inductor **100**; and Figure **5** is an isometric view showing the inside of the terminal table **14**. Figure **6** is a cross sectional view of the inductor **100** taken along lines **6 - 6'** shown in Figure **2**. Figure **7** is a cross sectional view of the inductor **100** taken along lines **7 - 7'** shown in Figure **2**.

With reference to Figure **1**, an inductor **100** includes a generally rectangular parallelepiped terminal table **14**, formed of an insulating material such as a heat-resistive resin, and six L-shaped conductors **10**. In detail, the terminal table **14** and the L-shaped conductors **10** are formed by insert-molding so that the L-shaped conductors **10** each extend from a longer side of the terminal table **14** to a shorter side thereof. Two ends of each L-shaped conductors **10** are projecting from the respective side of the terminal table **14**. Such projecting ends of the L-shaped conductor **10** are straight.

The projecting ends of the L-shaped conductors **10** on the shorter sides of the terminal table **14** each act as a terminal (hereinafter referred to as a "mounting terminal") **15** for mounting the inductor **100** on a printed circuit board. Each mounting terminal **15** is mounted on the printed circuit board in the state where a bottom surface thereof is in contact with the printed circuit board, and the bottom surface is on the same level as a bottom surface of the terminal table **14**.

The projecting ends of the L-shaped conductor **10** on the longer sides of the terminal table **14** each act as a terminal (hereinafter referred to as a "winding terminal") **16** around which an end of a wire is allowed to be wound. Each winding terminal **16** is projecting from an intermediate level part in the thickness direction of the respective side surface of the terminal table **14**. Thus, the winding terminals **16** are on a higher level than the mounting terminals **15**.

Such a difference in level between the mounting terminals **15** and the winding terminals **16** is realized by bending each L-shaped conductor **10** to have a stepped portion. The stepped portion is buried in the terminal table **14**.

Returning to Figure **2**, a drum-shaped core **12** is provided on a top surface of the terminal table **14**. The drum-shaped core **12** is surrounded by a cylindrical core **11**. The drum-shaped core **12** and the cylindrical core **11** form a magnetic core of the inductor **100**.

As is shown in Figures **6** and **7**, the drum-shaped core **12** has a top flange **12b** including a top surface of the drum-shaped core **12**, a bottom flange **12c** including a bottom surface of the drum-shaped core **12**, and a central part **12d** interposed between the top and bottom flanges **12b** and **12c** and having a smaller diameter than the top and bottom flanges **12b** and **12c**. The bottom surface of the bottom flange **12c** has a recess **12a**. On the other hand, the terminal table **14** has a projecting portion **14a** at the center portion of a top surface thereof. The drum-shaped core **12** is mounted on the terminal table **14** by engaging the projecting portion **14a** in the recess **12a**, and then is adhered on the terminal table **14**.

A wire **13**, for example, a copper wire, covered by an insulating material is wound around the central part **12d** of the drum-shaped core **12**. As is shown in Figure **1**, ends **9** of the wire **13** are wound around the winding terminals **16** for electric connection.

As is shown in Figures **4** and **5**, the terminal table **14** has two stepped-up portions **20** on the top surface along the shorter sides thereof. Further, projecting portions **19** are provided at four corners of the top surface; that is, on the stepped-up portions **20**. The projecting portions **19** and the stepped-up portions **20** are used for positioning the cylindrical core **11** and the drum-shaped core **12** on the terminal table **14**.

The drum-shaped core **12** and the cylindrical core **11** are mounted on the terminal table **14** in the following manner.

the stepped portion acts as a mounting terminal used for mounting of the inductor, the winding terminal being projecting from a higher level of the side surface of the terminal table than the mounting terminal.

In one embodiment of the invention, the terminal table has at least one groove running from one side to another side of a bottom surface thereof.

In another embodiment of the invention, the terminal table has a projection on the top surface thereof, the drum-shaped core has a bottom flange including a bottom surface of the drum-shaped core, and the bottom flange has a recess in the bottom surface, the recess being engageable with the projection of the terminal table.

In still another embodiment of the invention, the drum-shaped core has an outer circumferential surface which is held by an inner side circumferential surface of each of the projecting portions.

In still another embodiment of the invention, the terminal table further has a stepped-up portion between the top surface thereof and the projecting portions, and the magnetic core further includes another core located around the drum-shaped core. The drum-shaped core has an outer circumferential surface which is held by an inner side circumferential surface of the stepped-up portion. The another core has an outer circumferential surface which is held by an inner side circumferential surface of each of the projecting portions.

In still another embodiment of the invention, the another core is a cylindrical core located around the outer circumferential surface of the drum-shaped core.

In still another embodiment of the invention, the another core is a cap-like core covering a top surface and the outer circumferential surface of the drum-shaped core.

In still another embodiment of the invention, the level of the mounting terminals and the level of the winding terminals have a difference of approximately 0.2 mm to 1.0 mm, and the plurality of L-shaped conductors each have two stepped portions.

According to another aspect of the present invention, a method for producing an inductor includes the steps of: treating a strip-like metal plate with press working to form a lead frame and a terminal area interposed between two areas of the lead frame extending in a longitudinal direction of the strip-like metal plate, the lead frame and the terminal area being formed in a prescribed pattern; mounting a terminal table on the terminal area; mounting a magnetic core on the terminal table; winding a wire around the magnetic core; and separating an assembly including the terminal table, magnetic core, and the wire from the lead frame.

In one embodiment of the invention, the terminal area includes a plurality of L-shaped conductors, and the step of treating the strip-like metal plate with press working includes the step of forming at least one stepped portion in each of the plurality of L-shaped conductors to obtain a prescribed level difference between the level of one of two ends of each L-shaped conductor and the level of the other end of the L-shaped conductor.

In another embodiment of the invention, the step of forming at least one stepped portion includes the step of bending each of the L-shaped conductors a plurality of times to form two stepped portions to obtain the level difference of approximately 0.2 mm to 1.0 mm.

In still another embodiment of the invention, the method further includes the step of cutting off a part of each of the plurality of L-shaped conductors extending in a width direction of the strip-like metal plate from the lead frame before the step of mounting the terminal table.

In still another embodiment of the invention, the terminal area includes a plurality of L-shaped conductors. The step of treating the strip-like metal plate with press working includes the step of forming at least one stepped portion in each of the plurality of L-shaped conductors to obtain a prescribed level difference between the level of one of two ends of each L-shaped conductor and the level of the other end of the L-shaped conductor. One of the two ends which is on a higher level than the stepped portion acts as a winding terminal around which the wire is allowed to be wound, and the other end which is on a lower level than the stepped portion acts as a mounting terminal used for mounting of the inductor. The terminal table is mounted on the terminal area in such a manner as to allow the winding terminal to project from a higher level of a side surface of the terminal table than the mounting terminal.

Thus, the invention described herein makes possible the advantages of providing an inductor for surface mounting which includes a terminal having an improved size precision and is improved in productivity and mounting quality such as positional precision and reliability; and a method for producing such an inductor.

These and other advantages of the present invention will become apparent to those skilled in the art upon reading and understanding the following detailed description with reference to the accompanying figures.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure **1** is a partially cut perspective view of an inductor in an example according to the present invention;

Figure **2** is a perspective view of the inductor shown in Figure **1** showing an appearance thereof;

Figure **3A** is a top view, Figures **3B** and **3C** are side views, and Figure **3D** is a bottom view of the inductor shown in Figure **2**;

Figure **4** is an isometric view of a terminal table and terminals of the inductor shown in Figure **2**;

Figure **5** is an isometric view of the terminal table and terminals of the inductor shown in Figure **2**, illustrating the inside portion thereof;

Figure **6** is a cross sectional view of the inductor taken along lines **6 - 6'** in Figure **2**;

Figure **7** is a cross sectional view of the inductor taken along lines **7 - 7'** in Figure **2**;